

The Influence Of The Shallow Water Internal Tide On The Properties Of Acoustic Signals

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LONG-TERM GOAL

Quantitatively relate the temporal and spatial properties of shallow water acoustic signals to the physical processes that cause the temporal and spatial variability of the propagation channel. Address internal waves, tides, surface gravity wavefields and the heterogeneous ocean bottom/subbottom. Develop an ability to predict acoustic signal properties in the littoral.

SCIENTIFIC OBJECTIVES

Increase the understanding of the physics of broadband acoustic signal propagation through the random shallow water waveguide. Develop an ability to predict acoustic signal properties in the littoral.

APPROACH

This research is now being focused on the numerical modeling or replication of sound speed structure as controlled by barotropic tidal flow over bathymetric variability. It is our first attempt to develop the ability to predict acoustic field properties in the littoral.

The work is supported by data obtained during an interdisciplinary oceanographic and ocean acoustics experiment (SWARM95). That experiment's objective was to increase the basic understanding of the physics of acoustic signal propagation through slope/shelf internal wave fields. The experiment required extensive physical oceanographic measurements to quantify the generation, propagation and decay of those internal wave fields. It was conducted on the New Jersey Shelf during the summer of 1995. The acoustic propagation path was placed on the NSF Ocean Drilling Program Seismic Line 1003. An extensive ONR/NSF geologic and geophysical data set has been developed for this line and is being used to include the effects of the heterogeneous bottom on the acoustic signals. Two acoustics sources (224 Hz and 400 Hz) were placed at a distance of about 37 and 42 km from two vertical receiving arrays. Numerous thermistor arrays, temperature pods and bottom moored ADCP's were placed to monitor the properties of the water column.

WORK COMPLETED

The FY99's effort was focused two areas.

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In the first, we used high frequency acoustic flow visualization data to track the displacement of scattering horizons in an area where the sound speed profile was being controlled by barotropic flow over bathymetry. We integrated that data with ship ADCP and CTD data, and estimated the sound speed field change from slack to max ebb flow. We then calculated the impact that flow controlled variability in the sound speed field (slack to ebb tidal) would have on the complex acoustic field for the two sound speed fields. To establish a quantitative measure of the tidally controlled water column variability on acoustic systems the response of a Bartlett matched field processor (vertical array) was calculated for both the case of slack and ebb tidal flow. Differences between the two calculations were taken.

The second aspect of the effort involved providing sections of the SWARM95 high frequency acoustic backscattering to colleagues who used the data to perturb the measured range dependent sound speed structure at internal wave scales.

RESULTS

A sound speed profile was developed using SWARM95 tow-yo CTD data taken as the research vessel moved from shallow water (~ 35 m) to deeper water (~ 60 m). Shipboard ADCP data indicated the flow conditions to be caused by an ebb barotropic tide. There was evidence of flow separation and hydraulic jumps in the sound speed field. In the absence of CTD data taken during slack tide a sound speed profile was reconstructed using the fact that during slack tide flow periods isopycnals and associated iso-sound speed contours will not be displaced from their neutral buoyancy positions in the water column.

A plot (Figure 1) of the range dependent bottom depth and high frequency scattering layers (isopycnal surfaces) is shown. Iso-sound speed contours are assumed to follow the vertical displacement of the isopycnal scattering layers. Sound speed was calculated from the tow-yo CTD trajectories shown in the figure.

Complex acoustic fields were calculated for the case of ebb barotropic flow and slack flow sound speed profiles. Differences in the fields were apparent. The range depend array vertical gain (Bartlett Processor) from a source on the shelf to maximum range was calculated. The array gain, signal power and phase for the ebb flow and slack conditions were differenced and plotted. Significance differences in array gain were found (Figure 2).

These calculations show that a Bartlett processor will be sensitive to flow induced time/range varying sound speed fields.

Our next step is to determine if we can predict the barotropic flow induced sound speed variability using available hydrodynamic model. Using that predictive capability we hope to show that we will be able to predictably adapt in time and space matched field processors to temporally predictable sound speed field variability caused by barotropic flow over bathymetry.

IMPACT/APPLICATIONS

Results will permit the estimation of the temporal/spatial variability in phase coherent ASW system performance in shallow water propagation channels whose sound speed field is controlled by the barotropic tidal flow.

TRANSITIONS

None yet.

RELATED PROJECTS

Coupled to NRL projects addressing acoustic propagation through random littoral acoustics waveguide. Principle investigators involved in the NRL projects include S. Wolf and S. Finette.

Data used in this research was obtained during the ONR supported SWARM95 experiment as a collaborative effort between Dr. James Lynch and associates from the Woods Hole Oceanographic Institution; Dr. John Apel, Ocean Associates Inc.; Dr. Mohsen Badiy, The University of Delaware; Dr. C. S. Chiu, the NPGS; and scientists at the Naval Research Laboratory.

PUBLICATIONS

Finette, S., Orr, M.H., Turgut, A. and Apel, J.R., submitted to JASA 1999, " Acoustic field variability induced by time-evolving internal wavefields.

Apel, J.R., Finette, S. Orr, M. H. and Lynch, J. F., 1998, submitted to JGR; in review, "The "Dnoidal" Model for Internal Solitons and Tides on the Continental Shelf"

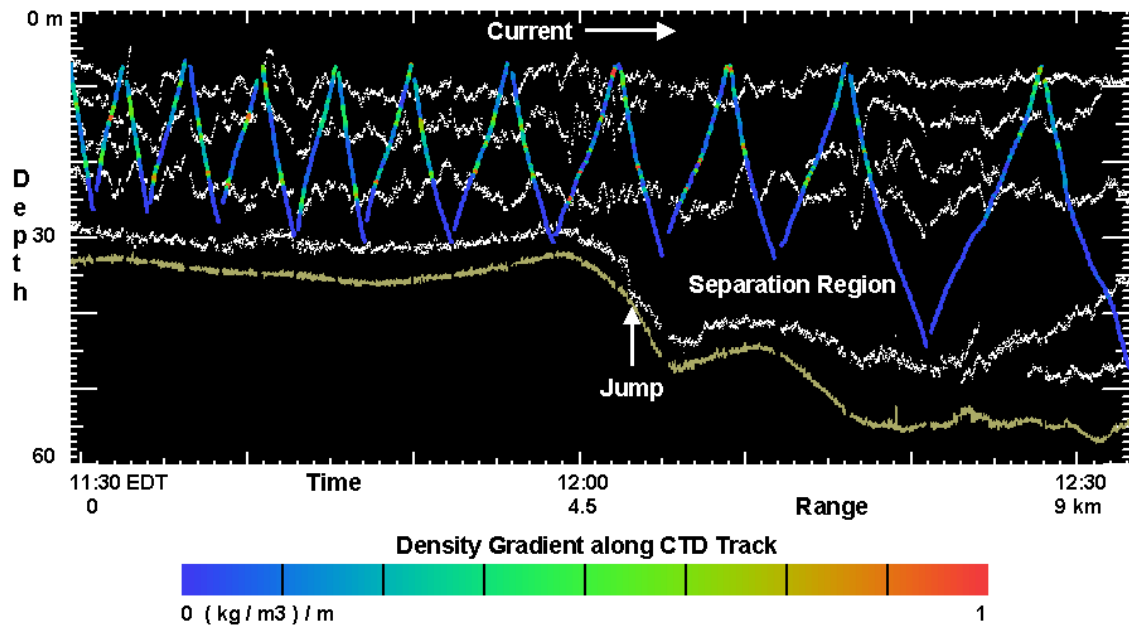
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Orr, M. H. and Mignerey, P., 1999, Flow Controlled Acoustic Propagation, Nov. 1999 Meeting ASA

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DENSITY GRADIENT



SWARM 25 July 1995

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Figure 1

RELATIVE FIELD LEVELS 50 m VERTICAL APERTURE (SWARM data)

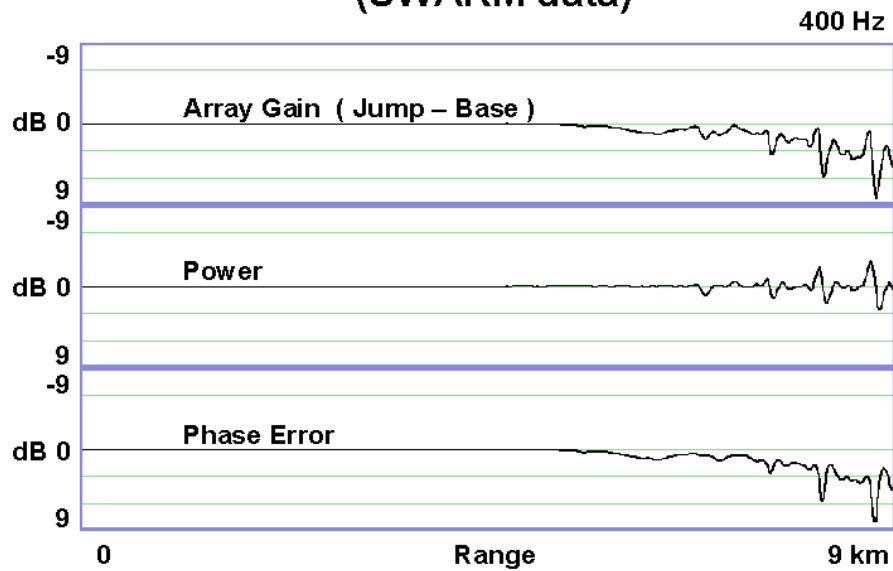


Figure 2